Exam 2

Instructions:

This is a closed-book closed-notes exam. You are permitted to use a calculator and the formula sheet provided, but no other written resources. Laptops are not permitted. If you feel that there is some information you need that is not provided, explain in your answer what this information is, and make some assumption that allows you to continue with the problem. In such a case, clearly state what your assumption is. I will not supply any additional information during the exam (other than to clarify the questions, if necessary).

Please put all work on the pages provided. If you run out of room in the space provided, you can continue on the back of the page (but clearly label which problem you are working on). **To receive full credit, you must show all your work, including intermediate calculations.** The method you use to solve the problems should be made clear. Include a brief sentence or two, where appropriate, explaining your procedure.

The duration of the exam is 50 minutes. When time is called, stop work and wait for further instructions on turning in your exam.

You might find the following equations useful:

\[
\begin{align*}
x &= x_0 + v_0 t + \frac{1}{2} a t^2 \\
v &= at \\
v_r &= \dot{r} \\
v_\theta &= r \dot{\theta} \\
a_r &= \ddot{r} - r \dot{\theta}^2 \\
a_\theta &= r \ddot{\theta} + 2 \dot{r} \dot{\theta} \\
p &= mv
\end{align*}
\]

\[
\begin{align*}
v &= v_0 + u \ln \left( \frac{m_0}{m} \right) \\
m &= m_0 - kt \\
v &= -gt + u \ln \left( \frac{m_0}{m} \right) \\
y &= ut - \frac{1}{2} gt^2 - \frac{um}{k} \ln \left( \frac{m_0}{m} \right) \\
\text{thrust} &= uk
\end{align*}
\]

\[
\begin{align*}
\mathbf{F} &= -\nabla \mathbf{U} \\
\nabla \times \mathbf{F} &= \begin{bmatrix} \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \end{bmatrix} \begin{bmatrix} F_x \\ F_y \\ F_z \end{bmatrix} \\
\nabla &= \frac{\partial}{\partial x} \hat{x} + \frac{\partial}{\partial y} \hat{y} + \frac{\partial}{\partial z} \hat{z} \\
\frac{d^2 \mathbf{X}}{dt^2} &= \sqrt{\frac{2}{m} \left[ \mathbf{E} - \mathbf{U}(\mathbf{X}) \right]} \\
\omega &= \sqrt{\frac{k}{m}} = \sqrt{\frac{\mathbf{U}''(\mathbf{X})}{m}} \\
\end{align*}
\]